Natural variability in stage/discharge relationship: From in situ measurements to the SWOT satellite error estimates

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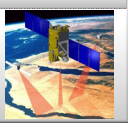
The SWOT mission

- The Surface Water Ocean Topography (SWOT) mission is a wide swath altimeter, with two 60 km swaths (with 10m to 70m across track resolution and 5m along track resolution). It will measure surface water elevation.
- 2 orbits have been considered:
  - Orbit 1: 20 day repeat period, 74° inclination and ~950km altitude.
  - Orbit 2: 22 day repeat period, 78° inclination and ~950km altitude.

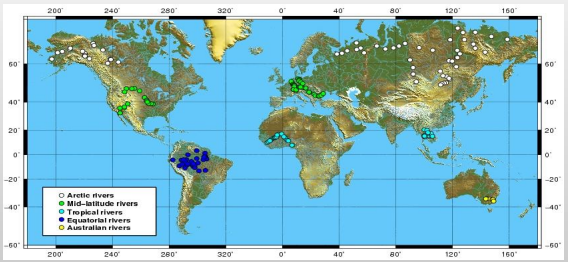


1. Error on the discharge due to the orbit temporal sampling

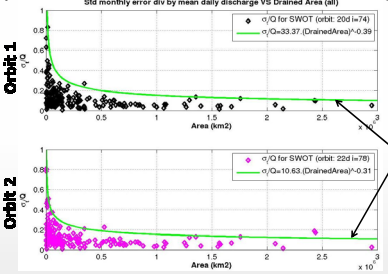
- (a) Hypothesis: SWOT measurement already converted in discharge
- (b) Methodology:
  - Gather in-situ daily discharges. Then extract the SWOT discharge time series (= dates where SWOT "see" the gauge).
  - Compute monthly mean discharge from daily (Qm_t, our "truth") and SWOT (Qm_{SWOT}) time series and then the sampling error:

$$\frac{\sigma_L}{Q} = \frac{std\left(Qm_t(month) - Qm_{SWOT}(month)\right)}{mean\left(Q_t\right)}$$

  - Classify these errors as a function of the river drainage area at the gauge location and then fit a relationship between the error and the drainage area.
- (c) Gauges used (from USGS, GRDC, ANA & HyBAM)

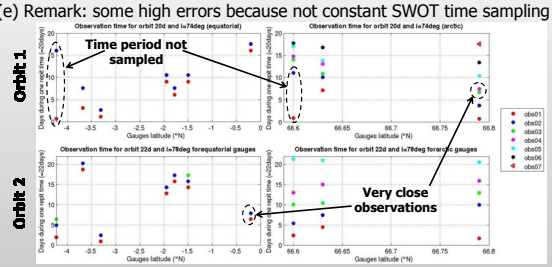


- (d) Results: errors due to the orbit temporal sampling vs drainage area



=> The fit allows to estimate discharge error wherever drainage area is known

- (e) Remark: some high errors because not constant SWOT time sampling



2. Error on the discharge due to the measurement error

- (a) Hypothesis: Power law relationship between discharge (Q) and river depth (D): $Q=c.D^b$ and $D=h-h_0$, h is the elevation measured by SWOT and h_0 is the river bed elevation.
- (b) Methodology: gather in-situ stage and discharge measurements. Then compute the error on the discharge estimate:

$$\frac{\sigma_Q}{Q} = \sqrt{\eta^2 + \left(b\,\frac{\sigma_D}{D}\right)^2}$$

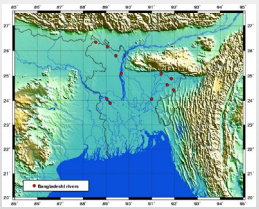
Model error (between true discharge and the one from power law)

Error due to the measurement error (σ_D)

Then estimate the value of η, *b* and D at the gauge location and finally extrapolate these results everywhere along the river.

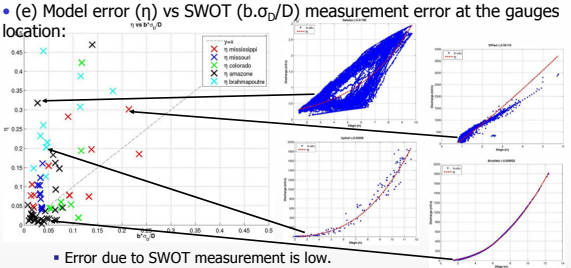
- (c) Gauges used (from USGS, GRDC, ANA & HyBAM):

64 gauges in America



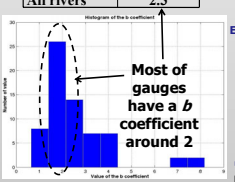
10 gauges in Bangladesh

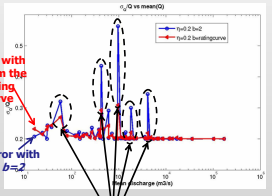
- (d) On river where there is no gauges, the river depth (D) can be estimated by using a power law relationship between river depth and drainage area (Moody and Troutman, 2002).
- (e) Model error (η) vs SWOT ($b.\sigma_D/D$) measurement error at the gauges location:



  - Error due to SWOT measurement is low.
  - Difficult to estimate model error (η): understimate if discharge not directly measured (most gauges), overestimate if different flow regimes (needs at least two different power laws). Can be estimated ~20% (Dingman and Sharma, 1997; Bjerklie et al., 2003)
- (f) Estimate of the *b* coefficient for all rivers (even with no gauges available):
  - From the gauges:

River	Median(b)
Amazon	2.0
Brahmaputra	3.2
Colorado	2.5
Mississippi	1.6
Missouri	3.8
All rivers	2.3





- => For rivers with no gauges and not too low river depth, b=2 is a good approximation

Conclusion

- Importance of the SWOT temporal sampling on the computation of monthly discharge.
- SWOT spatio-temporal errors have been computed from in-situ networks and for different satellite orbits.
- General hydrological parameters have been derived from these analysis.
- These parameters could be used to generate discharge error maps for a global river network.